U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

6.2.1.4 MASS AND ENERGY RELEASE ANALYSIS FOR POSTULATED SECONDARY SYSTEM PIPE RUPTURES

REVIEW RESPONSIBILITIES

Primary - Containment Systems and Severe Accident Branch (SCSB)[1]

Secondary - None

I. AREAS OF REVIEW

The SCSB reviews the analyses of the mass and energy release to assure that the data used to evaluate the containment and subcompartment functional design are acceptable for that purpose. The SCSB review includes the following areas:

1. The energy sources that are available for release to the containment.

2. The mass and energy release rate calculations.

The SCSB[2] also reviews the single-failure analyses performed for steam and feedwater line isolation provisions which would limit the flow of steam or feedwater to the assumed pipe rupture.

Review Interfaces[3]

In addition, the SCSB will coordinate other branches' evaluations that interface with the overall review of this area as follows:

1. The Mechanical Engineering Branch (EMEB)[4] is responsible for reviewing the seismic classification and system quality group classification of steam and feedwater line isolation valves to determine the acceptability of these valves in limiting the mass and energy releases from the steam and feedwater system as part of its primary review responsibility for ~~(see~~ Standard Review Plan Sections 3.2.1 and 3.2.2~~)~~.[5] The EMEB will also review postulated pipe break locations and sizes as part of its primary review responsibility for SRP Section 3.6.2.[6]

2. The ~~Auxiliary Systems Branch (ASB)~~Plant Systems Branch (SPLB)[7] reviews the time assumed for operator action to close manual valves in the auxiliary feedwater system as part of its primary review responsibility for~~(see~~ Standard Review Plan Section 10.4.9~~)~~.[8]

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

The SCSB[9] acceptance criteria is based on meeting the requirements of General Design Criterion (GDC) 50, with respect to providing sufficient conservatism ~~conservation~~[10] in the mass and energy release analysis for postulated PWR secondary system pipe ruptures to assure that the containment design margin is maintained.

Specific criteria necessary to meet the relevant requirements of GDC 50 are as follows:

1. Sources of Energy

The sources of energy that should be considered in analyses of steam and feedwater line break accidents include: the stored energy in the affected steam generator's metal, including the vessel tubing, feedwater line, and steam line; the stored energy in the water contained within the affected steam generator; the stored energy in the feedwater transferred to the affected steam generator prior to closure of the isolation valves in the feedwater line; the stored energy in the steam from the unaffected steam generator(s) prior to the closure of the isolation valves in the steam generator crossover lines; and the energy transferred from the primary coolant to the water in the affected steam generator during blowdown.

The steam line break accident should be analyzed for a spectrum of pipe break sizes and various plant conditions from hot standby to 102% of full power. Only the 102% power condition need be analyzed provided the applicant can demonstrate that the feedwater flows and fluid inventory are greatest at full power.

2. Mass and Energy Release Rate Calculations

In general, calculations of the mass and energy release rates during a steam or feedwater line break accident should be done in a manner that is conservative from a containment response standpoint; i.e., that maximizes the post-accident containment pressure and temperature. The following criteria indicate the degree of conservatism that is desired.

Mass release rates should be calculated using the Moody model (Reference ~~.~~ 26~~16~~)[11] for saturated conditions, or a model that is demonstrated to be equally conservative.

Calculations of heat transfer to the water in the affected steam generator should be based on nucleate boiling heat transfer.

Calculations of mass release should consider the water in the affected steam generator and feedwater line, the feedwater transferred to the affected steam generator prior to the closure of the isolation valves in the feedwater lines, the steam in the affected steam generator, and the steam coming from the unaffected steam generator(s) as the secondary system is being depressurized prior to the closure of the isolation valves in the steam generator crossover lines.

If liquid entrainment is assumed in the steam line breaks, experimental data should support the predictions of the liquid entrainment model. The effect on the entrained liquid of steam separators located upstream from the break should be taken into account. A spectrum of steam line breaks should be analyzed, beginning with the double-ended break and decreasing in area until no entrainment is calculated to occur, to allow selection of the maximum release case.

If no liquid entrainment is assumed, a spectrum of the steam line breaks should be analyzed beginning with the double-ended break and decreasing in area until it has been demonstrated that the maximum release rate has been considered.

A single active failure in the steam or feedwater line isolation provisions or feedwater pumps, such that the containment peak pressure and temperature are maximized, should be assumed to occur in steam and feedwater line break analyses. For the assumed failure of a safety grade steam or feedwater line isolation valve, operation of nonsafety grade equipment may be relied upon as a backup to the safety grade equipment. In this event, the SCSB[12] reviewer will confer with the ~~ASB~~ SPLB[13] and EMEB[14] reviewers to ensure a consistent staff position regarding the acceptability of the design criteria for the nonsafety grade equipment.

Feedwater flow to the affected steam generator should be calculated considering the diversion of flow from the other steam generators, feedwater flashing and increased feedwater pump flow caused by the reduction in steam generator pressure. An acceptable method for computing feedwater flow is to assume all feedwater travels to the affected steam generator at the pump runout rate before isolation. After isolation, the unisolated feedwater mass should be added to the affected steam generator. The RELAP4 code (Reference 3)[15] may also be used to compute feedwater flow.

Operator action to terminate auxiliary feedwater flow will be reviewed by ~~ASB~~SPLB as part of its review responsibility under~~. (See~~ SRP Section 10.4.9.~~)~~[16]

Acceptable computer codes for calculating mass and energy releases for steam line breaks are SGN-III (Reference~~:~~ 16~~19~~)[17] and TRAP-2 (Reference~~:~~ 15~~31~~).[18] Other methods will be acceptable if they are found by SCSB[19] to be conservative for these calculations.

Technical Rationale[20]

The technical rationale for application of the above acceptance criteria to the mass and energy release analysis for postulated loss-of-coolant accidents is discussed in the following paragraph.

GDC 50 requires the containment structure and associated heat removal system to be designed with margin to accommodate any loss-of-coolant accident such that the containment design leak rate is not exceeded. SRP Section 6.2.1.4 applies the requirements of this GDC to postulated PWR secondary system pipe ruptures to assure that mass and energy inputs are appropriately conservative. A secondary system pipe rupture releases a significant amount of energy which potentially could damage the containment structure or associated systems. Containment, therefore, must be designed to definitively withstand this accident. Meeting GDC 50 will ensure that containment integrity is maintained under the most severe secondary system pipe rupture, thus precluding the release of radioactivity to the environment.

III. REVIEW PROCEDURES

The procedures described below are followed for the review of the mass and energy release analysis of secondary coolant systems pipe breaks. The reviewer selects and emphasizes material from these procedures as may be appropriate for a particular case. Portions of the review may be carried out on a generic basis or by applying the results of previous reviews of similar plants.

The SCSB[21] reviews the secondary coolant system pipe breaks analysis assumptions to determine whether the "worst" pipe break accident case has been identified by the applicant, and whether the analysis was done in a conservative manner from the standpoint of containment pressure and temperature.

This review involves the proposed methods and models used for blowdown analyses. The acceptability of the approach used by the applicant is evaluated based on the acceptance criteria in subsection II of this SRP section. The SCSB[22] also reviews analyses of postulated single failures of active components in the secondary systems, such as steam and feedwater line isolation valves and feedwater pumps, to determine whether the single failure has been selected which maximizes containment pressure and temperature.

The SCSB will request EMEB[23] to review the acceptability of nonsafety valves in limiting the mass and energy releases from the steam and feedwater systems. The SCSB will request the ~~ASB~~SPLB[24] to review the rationale for determining the time at which operator action can be relied upon to terminate auxiliary feedwater flow to the affected steam generator. The SCSB[25]

will review the applicant's calculations for main feedwater flow into the affected steam generator to determine that the flow rate is conservatively maximized.

If liquid entrainment is calculated in the applicant's steam line break model, the SCSB will determine the validity of the experimental data provided to support the entrainment calculation. The SCSB will also ascertain that the effect of steam separators located upstream from the postulated steam line break have been taken into account in the analysis. The SCSB[26] reviews comparisons to experimental data made by the applicant and makes comparisons to other available experimental data to determine the amount of conservatism in the mass and energy release models.

The SCSB[27] reviews the results of a spectrum of steam line breaks, beginning with the double-ended break and decreasing in area until no entrainment occurs, to be sure that the steam line break size producing the highest containment temperature and pressure has been identified.

The SCSB[28] performs confirmatory analyses of the containment pressure and temperature response to steam and feedwater line breaks inside the containment using the CONTEMPT-LT computer code (References 20 and 21)[29].

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[30]

IV. EVALUATION FINDINGS

The conclusions reached on completion of the review of this SRP section are presented in Standard Review Plan Section 6.2.1.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[31] Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.[32]

VI. REFERENCES

The references for this SRP section are listed in Standard Review Plan Section 6.2.1.

SRP Draft Section 6.2.1.4
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section.
2.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section (3 identical changes in this paragraph).
3.	SRP-UDP format item, Reformat Areas of Review	Added "Review Interfaces" heading to Areas of Review. Reformatted existing description of review interfaces in numbered format to describe how SCSB reviews aspects of the secondary mass and energy release analysis under other SRP sections and how other Branches support the review.
4.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for SRP Sections 3.2.1 and 3.2.2.
5.	SRP-UDP format item	Added the phrase "as part of its primary review responsibility for" for clarity, consistency with other SRP sections, and to meet SRP-UDP guidance.
6.	Editorial	Added a Review Interface with SRP Section 3.6.2 regarding review of pipe locations and sizes. SRP Section 6.2.1.4 involves the review of mass and energy releases from postulated pipe ruptures outside containment. The review of postulated pipe rupture locations and sizes is the responsibility of the EMEB under SRP Section 3.6.2 and therefore this interface is appropriate. The addition of the interface with SRP Section 3.6.2 is also consistent with the existing interface in SRP Section 6.2.1.3, which provides for review of mass and energy releases inside containment.
7.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for SRP Section 10.4.9.
8.	SRP-UDP format item	Added the phrase "as part of its primary review responsibility for" for clarity, consistency with other SRP sections, and to meet SRP-UDP guidance.
9.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section.
10.	Editorial	"Conservation" was changed to "conservatism". It is assumed that the word "conservation" was meant to be "conservatism" since the former word does not make sense in this application. This change adds clarity to the sentence.

Item	Source	Description
11.	SRP-UDP format item	Format change to make the citation of references consistent with SRP-UDP guidance. The reference number was revised to be consistent with changes made in the Reference section of SRP 6.2.1.
12.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section.
13.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for SRP Section 10.4.9.
14.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for SRP Sections 3.2.1 and 3.2.2.
15.	SRP-UDP format item/Unverified reference	Format change to make the citation of references consistent with SRP-UDP guidance. This reference cannot be verified to be the most current reference that is still approved by the NRC.
16.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for SRP Section 10.4.9. Added the phrase " as part of its review responsibility under" to clarify the sentence and add consistency.
17.	SRP-UDP format item	Format change to make the citation of references consistent with SRP-UDP guidance. The reference number was revised to be consistent with changes made in the Reference section of SRP 6.2.1.
18.	SRP-UDP format item	Format change to make the citation of references consistent with SRP-UDP guidance. The reference number was revised to be consistent with changes made in the Reference section of SRP 6.2.1. This reference cannot be verified to be the most current reference that is still approved by the NRC.
19.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section.
20.	SRP-UDP format item, Develop Technical Rationales	Added Technical Rationale for GDC 50. Technical Rationale is a new SRP-UDP format item.
21.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section.
22.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section.
23.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for SRP Sections 3.2.1 and 3.2.2.
24.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for SRP Section 10.4.9. Added the phrase " as part of its review responsibility under" to clarify the sentence and add consistency.

Item	Source	Description
25.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section (3 identical changes in this paragraph).
26.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section (3 identical changes in this paragraph).
27.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section.
28.	Current PRB names and abbreviations	Editorial change made to reflect current PRB name and responsibility for this SRP Section.
29.	SRP-UDP format item	Format change to make the citation of references consistent with SRP-UDP guidance. These references cannot be verified to be the most current references that are still approved by the NRC.
30.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
31.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
32.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.

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Integrated Impact No.	Issue	SRP Subsections Affected
	No integrated impacts were incorporated in this SRP Section.	